Section 9 Water Planning and Development

9.1 Introduction 9-1

9.2 Background 9-1
9.2.1 Dixie Project 9-4
9.2.2 Recent Water Development 9-5
9.2.3 Current Water Development 9-6

9.3 Policy Issues and Recommendations 9-6
9.3.1 Preservation of Potential Reservoir Sites 9-6
9.3.2 Development in Proposed Wilderness Study Areas and and Wild and Scenic River Segments 9-7
9.3.3 Long Range Management Plans 9-7

9.4 Water Resources Problems 9-10

9.5 Water Resources Demands and Needs 9-10
9.5.1 Culinary Water 9-11
9.5.2 Secondary Systems 9-11
9.5.3 Irrigation Water 9-11
9.5.4 Recreational Water Demands 9-12
9.5.5 Fish and Wildlife Water Needs 9-14

9.6 Water Supply Enhancement 9-14

9.7 Water Development and Management Alternatives 9-15
9.7.1 Groundwater 9-15
9.7.2 Water Conveyance and Delivery Systems 9-15
9.7.3 Water Storage Facilities 9-16
9.7.4 Virgin River/Cedar City Transfer 9-16
9.7.5 Water Supply Management 9-22

9.8 Projected Basin Water Depletions 9-23

9.9 Cloud Seeding 9-24

9.10 References 9-25

Tables

9-1 Water Development Projects 9-2
9-2 Wilderness Study Areas 9-8
9-3 Current and Projected Culinary Water Use 9-11
9-4 Current and Projected Secondary Water Use 9-12
9-5 Potential Reservoirs, Over 3,000 acre-feet, Virgin River 9-18
9-6 Potential Reservoirs, Under 3,000 acre-feet, Virgin river 9-19
9-7 Potential Reservoirs, Kanab Creek/Johnson Wash 9-20
9-8 Current and Projected Water Depletions 9-24

Figures

9-1 Wilderness Study Areas and Wild and Scenic River Segments 9-9
9-2 Potential Recharge Area, Navajo Sandstone Aquifer 9-17
9-3 Potential Reservoir Sites, Kanab Creek/Virgin River Basin 9-21

9 Water Planning and Development

Wise planning for water conservation and development is essential to properly meet the needs and demands of a growing population in the Kanab Creek/Virgin River Basin. This will require cooperation of all government and local groups.

9.1 Introduction

This section describes the existing and proposed water planning and development activities in the basin. State and federal agencies and other interested parties should recognize water as a resource to provide for the needs of local communities and citizens while keeping in mind the aesthetic and environmental values. Considerable water-related activity is already under way, particularly in Washington County where population and employment are increasing at the highest rate in the state.

The goal of the Division of Water Resources and other water-related agencies is to assist in the coordination needed to make future planning and development as effective as possible. However, the decision-making process is still the responsibility of the local entities. This plan is intended to provide local decision makers with data to help them solve existing problems and provide for future needs with the most viable alternative.

9.2 Background

As stated in earlier sections, considerable planning and development has been accomplished in the area. Early activities were by groups of individuals with a common cause. Later, these became formal incorporated irrigation companies and cities. Since then, water conservancy districts have been formed in Kane and Washington counties. On occasion, several irrigation companies and/or groups have joined to pursue development of a common water project. A variety of other entities, such as special service districts, have been formed to develop needed water. Some of the sponsors and developments assisted by the Board of Water Resources are shown in Table 9-1.

TABLE 9-1
WATER DEVELOPMENT PROJECTS

Sponsor	Type[a]	Year
Iron County		
Kanarraville Town	CL, Well	1948
Spring Cr. & La Verkin Cr. Irr. Co.	Res., Dam	1983
Kane County		
Glendale Irr. Co.	Pond, Spk.	1984
Kanab City	CL, PL, Well	1983-88
Kanab Irr. Co.	Div., PL	1983
Mt. Carmel Irr. Co.	Div., CNL	1956-61
Mt. Carmel Pipe Line Co.	CL, Well, PL	1979
Mt. Carmel SSD	CL, PL, Tank	1982
Orderville Irr. Co.	Div., PL	1956-69
Washington County		
Ash Creek Irr. Co.	Res. Dam	1958-87
Baker Reservoir Association	Res. Dam	1950
Bench Lake Irr. Co.	Res. Dam, CNL, PL	1957-76
Black Canyon Irr. Co.	Div., PL	1984
Central Canal & Irr. Co.	Div., CNL, Pond, Spk.	1972-82
Central Culinary Water Assoc.	CL, Tank, PL	1984
Hall & Grafton Irr. Co.	PL	1986
Hurricane Canal Co.	PL, CNL	1960-91
Hurricane City	CL, Tank, PL, Ds	1978-92
Ivins Irr. Co.	CNL, PL	1976
Ivins Town	CL, PL	1979
Kolob Res. & Storage Assoc.	Res. Dam	1956
La Verkin City	CL, Pump, Tank, PL	1976-82
Leeds Domestic Water Users Assoc.	CL, Tank, Well	1976-90

TABLE 9-1 (continued)
WATER DEVELOPMENT PROJECTS

Leeds Water Co.	Div., CNL	1972
Lower Gunlock Res. Corp.	Res. Dam	1970
New Harmony Res. Irr. Co.	PL, CNL	1963-85
Pine Valley Irr. Co.	CL, PL, Spring Div.	1975-82
Pine Valley Mtn. Farms Irr. Co.	CL	1990
Rockville Pipeline Co.	CL, Well	1975
Rockville Town Ditch Co.	Div., PL, Spk.	1968-90
Santa Clara City	CL, Well, Tank, Pipe	1979
Silver Reef SSD	CL, Tank, PL, Spk	1980
South New Harmony Canal Co.	Div., Spk.	1975
Springdale Consolidated Irr. Co.	Dual Sys.	1988
St. George & Washington Canal Co.	Div., CNL	1974-89
St. George City	CL, Treat.	1990
Trees Ranch Ltd.	Res. Dam	1988
Veyo Irr. Co.	CNL	1961
Virgin Canal Co.	Spk.	1972
Virgin Town	Well, Tank, Treat.	1978-84
Washington City	Tank, PL, Well	1976-82
Washington County Water Con. Dist.	Div., Res. Dam	1983-90

Note: Projects assisted by the Board of Water Resources

[a]CL - Culinary line
Res. - Reservoir
Spk. - Sprinkler
PL - Pipeline
Div. - Diversion
CNL - Canal lining
Treat.- Treatment plant
Ds - Dual system

Also refer to Tables 8-1 and 8-2 for state and federal expenditures.

As the demands for municipal and industrial (M&I) water increase, the supplies will come primarily from water right transfers, new water development and conservation. Additional supplies can be developed primarily from Virgin River surface water or from groundwater in the basinwide Navajo sandstone aquifers. Water conservation can meet a part of future needs. Of the total water depleted for all uses, not including riparian and wetland, about 63 percent is for agricultural purposes. This will decrease to 25 percent as other demands increase. The current depletion for M&I water is 13 percent, but it will increase to 34 percent by 2040.

Water conservation can reduce the M&I water diversion in several ways. This can be accomplished by installing water saving fixtures inside the home and by reducing outside water use. Xeriscaping and use of secondary systems are the best ways to conserve culinary water used outside.

Increasing irrigation water use efficiencies is the most effective way to conserve agricultural supplies. This can be accomplished by installing canal lining, pipelines, and sprinkler irrigation systems. Also see Section 17, Water Conservation.

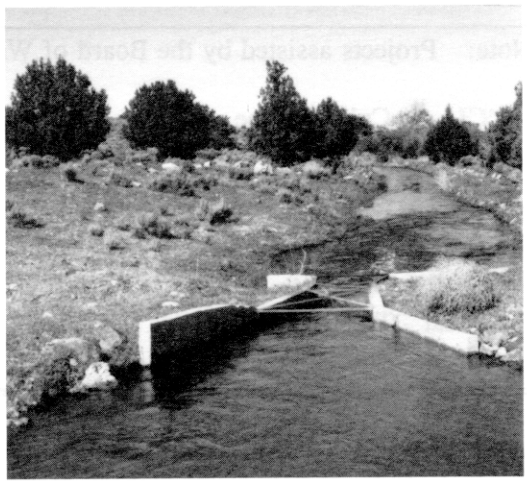
The M&I and agricultural water needs in the states of Arizona and Nevada are other demands on the Virgin River system. This is particularly true in the Las Vegas area where the M&I demands are accelerating at a high rate.

9.2.1 Dixie Project

After the passage of the Federal Reclamation Act of 1902, many studies and investigations relating to the Dixie Project were conducted between 1902 and 1937. Most important of these early investigations is one made by H. H. Kleinschmidt for the state of Utah and reported in the *Seventh Biennial Report of the State Engineer of Utah, 1909 and 1910.* The Bureau of Reclamation published a report in 1937 entitled *Report on Dixie Project Investigations, Utah*, which summarized many technical investigations as well as general investigations conducted by the State of Utah, Bureau of Reclamation, the Mormon Church and the Utah Power and Development Company (Utah Power & Light Company).

Subsequent re-study and updating resulted in the Dixie Project being submitted to Congress for authorization. The project was finally authorized for construction September 2, 1964, and a *Definite Plan Report* was published in June 1967.

After project authorization, detailed studies of the Virgin City Reservoir, a key feature of the project, revealed the probability of excessive reservoir leakage at the site selected. This would require costly subsurface treatment to correct.



This required a search for another dam and reservoir site, resulting in the selection of a new site about 15 miles downstream. This change required considerable modification of project facilities, including the elimination of power development as a project feature. With this change, the project's financial status changed from one which could pay for itself to one requiring other financial assistance. The financial status also was aggravated by rising construction and operation costs, and the elimination of some lands from the project because of inherent drainage problems.

On September 30, 1968, the project was re-authorized for construction at a site determined feasible by the Secretary of the Interior. It also provided financial integration into the Lower Colorado River Basin Development Fund and an increase in the appropriation ceiling. The 1968 plan of development contained essentially all of the multipurpose functions of the originally authorized project. However, the construction of Lower Gunlock Reservoir on the Santa Clara River was eliminated. The Lower Gunlock Reservoir was constructed in 1970 by the Lower Gunlock Reservoir Corporation.

Between 1969 and 1972, the Dixie Project again underwent major changes. Also, as a result of the Environmental Protection Act of 1969, a search began for a project with less impact on the environment. The reformulation studies resulted in a project deemed better suited to the needs of the people of southwestern Utah and more adaptable to the statewide water plan. It would provide higher quality water and would be better environmentally. The reformulated project replaced the Virgin River Dam and Reservoir with an offstream storage site in Warner Valley located about eight miles east of St. George, Utah.

In February 1973, the directors of the Washington County Water Conservancy District met and elected to accept the offer of the Allen-Warner Valley Energy System sponsors and to reject the alternative of the Dixie Project proposed by the Bureau of Reclamation. This ended efforts to work with the Bureau of Reclamation.

The Allen-Warner Valley Energy System Project experienced many problems with the environmental review and permitting process. The energy system was delayed and, eventually, work on the Warner Valley Water Project was stopped.

9.2.2 Recent Water Development

The effort to develop the water resources continues. The Washington County Water Conservancy District, with assistance from the Board of Water Resources, completed the Quail Creek Project in 1985. Quail Creek Reservoir has a total capacity of 40,325 acre-feet. The primary water supply is diverted from the Virgin River above Hurricane via a diversion dam and pipeline.

Four projects, Pine Valley, Baker, Lower Gunlock and Ivins reservoirs, provide approximately 13,000 acre-feet of storage on the Santa Clara River system. Two projects, Kolob and Ash Creek reservoirs, have been built on tributaries in the upper part of the Virgin River. Kolob Reservoir, located in the head waters of the North Fork of the Virgin River, has an active storage of 5,586 acre-feet. Ash Creek Reservoir has experienced leakage since the time it was constructed. Storage is now 3,175 acre-feet. There are three other small reservoirs: Blue Springs on North Creek, Aspen Lake on Deep Creek and Stratton Reservoir

(offstream) below Quail Creek dam.

Glendale Irrigation Company has installed a pond and sprinkler irrigation system. Orderville Irrigation Company and Mt. Carmel Irrigation Company have installed diversions, a pipeline and canal lining. A culinary well and storage tank were installed by Mt. Carmel Pipeline Company and Special Service District. Canal lining, pipelines and a well have been constructed in the Kanab area. Several sprinkler irrigation systems have been installed in Johnson Wash.

9.2.3 Current Water Development

Projects currently in various stages of development are Springdale Water Treatment Plant Improvements, Kanab City Culinary Well, and the Hurricane Secondary (Dual) Water System. Other unknown projects may be underway.

9.3 Policy Issues and Recommendations

Three policy issues are discussed. These are 1) preservation of potential reservoir sites, 2) development in proposed wilderness areas and wild and scenic river segments and 3) long-range conservation and development plans.

9.3.1 Preservation of Potential Reservoir Sites

Issue - Feasible reservoir sites are becoming harder to find.

Discussion - Construction of additional water storage facilities is needed in order to provide for projected needs and demands. Other developments often infringe on these sites, prohibiting their use for water storage facilities or requiring expensive relocation costs. Also, the possible development of some sites is prevented when the areas are withdrawn for other purposes such as proposed wilderness areas or for wild and scenic river designation.

Preservation of potential reservoir sites would eliminate this problem. Over the years, more than 100 potential reservoir sites have been investigated. Investigation detail varies from cursory on-site evaluations to minor geotechnical work. Many of the sites have been or will be disqualified in the future as more detailed investigations or other factors eliminate them from consideration. In the final analysis, only a few of the sites will actually be utilized to provide water storage.

Reservoir site protection proposals should have public input. The Forest Service and Bureau of Land Management should identify

and evaluate potential reservoir storage sites in their planning processes. See Section 9.7.3 and Tables 9-5 thru 7.

Recommendation - The Washington and Kane counties water conservancy districts and other appropriate entities should act to protect potential water storage sites.

9.3.2 Development in Proposed Wilderness Study Areas and Wild and Scenic River Segments

Issue - Designation of proposed wilderness areas and wild and scenic river segments may restrict or prohibit future development, use and maintenance of needed water supplies and facilities.

Discussion - Two wilderness areas exist in the Kanab Creek/Virgin River Basin. These are 1) Beaver Dam Mountain, 3,788 acres and 2) Pine Valley Mountain, 50,000 acres. There are several wilderness study areas with a total area of over 152,000 acres. Several of the proposed wilderness study areas contain potential sites for wells and sources of surface water which could be used to meet future municipal and industrial (M&I) water needs. There are potential reservoir sites in some of the wilderness study areas and wild and scenic river segments where high flows could be stored for multiple purposes, including M&I, irrigation, recreation, flood control and instream flow water uses. Existing water developments could still be used, but future access for operation and maintenance may be more difficult. After wilderness study areas and wild and scenic river segments are designated, new development cannot take place.

The wilderness areas proposed by the Bureau of Land Management are listed in Table 9-2 and shown on Figure 9-1. In-holding areas are not included in the acreage. The wild and scenic river segments are shown on Figure 9-1.

Recommendation - Water users, county commissioners, mayors, and state officials should continue to keep Congress and appropriate federal agencies aware of the need to allow watershed improvement and surface water and groundwater resources development by excluding these areas when making wilderness and wild and scenic river segment designations.

9.3.3 Long-Range Management Plans

Issue - There is a need for long-range coordinated planning for the management of the water resources at all levels of government.

Discussion - Water use in the basin will increase in the future. A rapidly expanding population, especially in Washington County which encompasses much of the basin, will increase the M&I use of water. The place of use of agricultural water will also change in the future. Some agricultural lands will be taken out of production and the water converted to M&I uses and some new lands may be developed. Water supplies for

TABLE 9-2
WILDERNESS STUDY AREAS

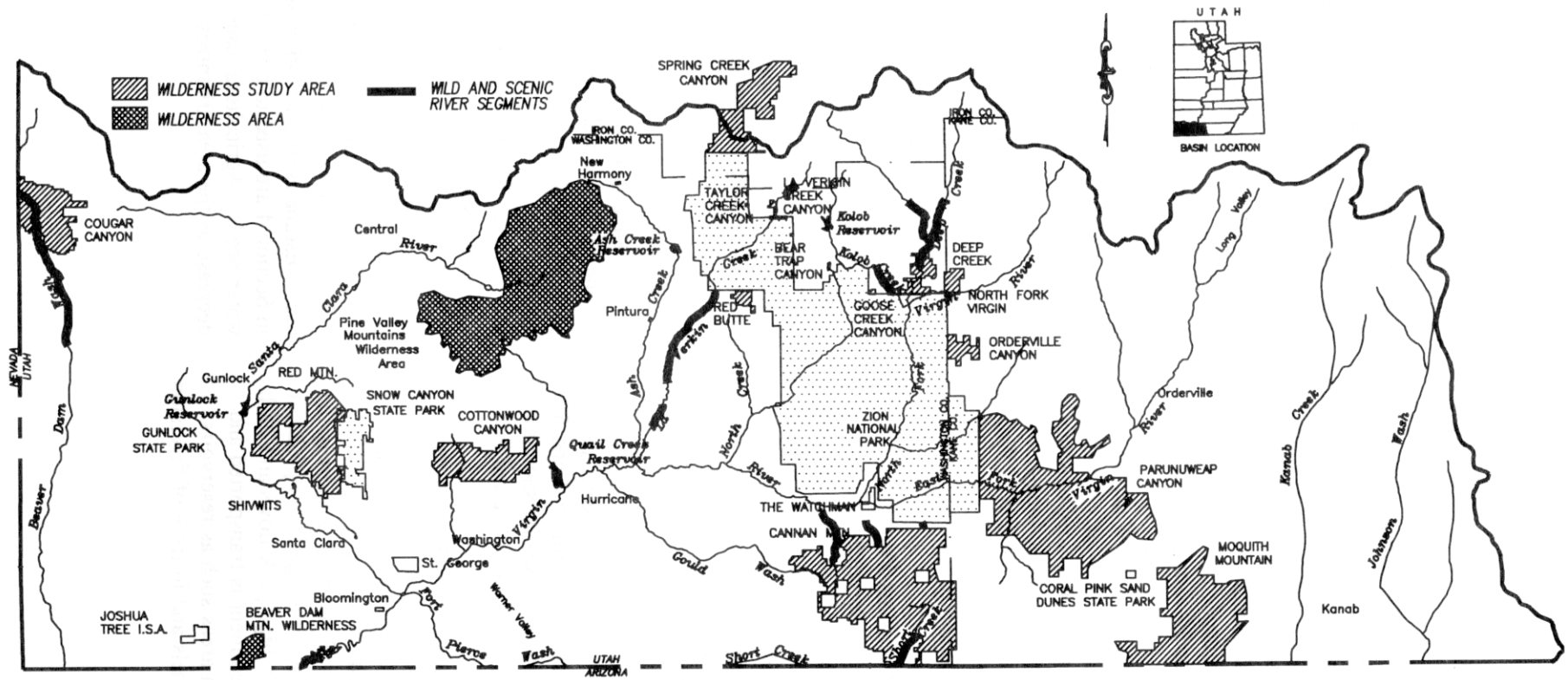
WSA Name	Acreage
Cougar Canyon	15,968
Red Mountain	18,290
Cottonwood Canyon	11,330
La Verkin Creek Canyon	567
Deep Creek	3,320
Canaan Mountain	47,170
Red Butte	804
Spring Creek Canyon	4,433
The Watchman	600
Taylor Creek Canyon	35
Goose Creek Canyon	89
Bear Trap Canyon	40
(Joshua Tree ISA)[a]	1,040
North Fork Virgin River	1,040
Orderville Canyon	1,750
Parunuweap Canyon	30,800
Moquith Mountain	14,830
TOTAL	152,106

[a]Instant Study Area
Source: Bureau of Land Management

agricultural lands that experience frequent shortages could be firmed up.
Other important factors affecting future water availability are federal reserve claims, instream flow requirements and designation of critical habitat and wild and scenic river segments. Also, areas of critical environmental concern, special recreation management areas and Visual Resource Management Class I and II will impact future water availability.

Long-range plans will be required in order to best develop and conserve the water

FIGURE 9-1
Wilderness Study Areas and Wild and Scenic River Segments



resources to meet all the demands. These plans should include buildout studies as appropriate. These plans should also include the quantity and quality of water available from presently developed sources as well as institutional, physical and hydrologic limits. Separate plans are needed for the Virgin River basin and the Kanab Creek/Johnson Wash drainages.

Recommendation - The Washington and Kane counties water conservancy districts should take the lead to inventory existing resources and prepare specific long-range management plans. The Division of Water Resources and other appropriate state and federal agencies should provide assistance.

9.4 Water Resources Problems

The major water resources problem is providing adequate supplies at the location and time needed. Often, sufficient annual supplies are available but the peak supply is at a different time than the peak need. Also, there is generally a problem of conveying water from one location to another because of water rights, cost and environment concerns. The variation in flows is shown by gaged records of the Virgin River near the town of Virgin. See Figure 5-4 and 5-5. This variability can be caused by snow-melt runoff, cloudburst floods and wet and dry periods.

Certain parts of the basin are prone to flash flooding from rainfall. The instantaneous peak flows from these flash floods can be high and cause erosion and property damage. Sediment transport in the basin, that can also be a significant problem, is compounded by high peak flows and flash flooding. The sediment is transported and then deposited in areas such as reservoirs and stream channels and in front of diversion dam structures. When on-stream reservoirs are built, such as Gunlock Reservoir, a portion of the original storage volume is required for the sediment trapped in the reservoir. Sediment accumulation reduces the effective water storage capacity of reservoirs.

In the Kanab Creek/Virgin River Basin, usable quantities of groundwater occur in consolidated and unconsolidated rock. Presently, the unconsolidated aquifers produce more water than consolidated rock formations such as the Navajo sandstone; however, total groundwater storage is greater in the consolidated formations. Water quality in both aquifers tends to be better at higher elevations in the tributaries, but good and poor quality may be found in many areas. The unconsolidated aquifers generally have poorer quality water in the lower elevations of the basin due to discharge from some geological formations containing soluble minerals. Additional discussion on groundwater is given in Sections 9.7.1 and 19.

Providing adequate, high quality water for municipal and industrial (M&I) use will be one of the most challenging problems for years to come.

9.5 Water Resources Demands and Needs

Demands for water to satisfy various users will continue to increase. Because of economic status, municipal and industrial (M&I) water demands will continue to be the catalyst for the transfer of water from other uses. Estimates of population growth given in Section 4 are used to project future M&I water needs. Agricultural uses are likely to decrease as the area urbanizes. Reserved

TABLE 9-3
CURRENT AND PROJECTED CULINARY WATER USE

Year	County			Total	
	Iron	Kane	Washington	Diversion	Depletion
			(acre-feet)		
1990	90	1,670	18,570	20,330	10,570
2000	100	2,390	30,000	32,490	17,540
2010	110	2,880	39,800	42,790	23,960
2020	130	3,300	47,700	51,130	29,660
2040	210	4,500	78,000	82,710	51,280

water claims and instream flows are discussed in Section 7 and 6, respectively.

9.5.1 Culinary Water

Table 9-3 shows the current and projected culinary water diversions and depletions. It is estimated the culinary water use will increase about two and one-half times by the year 2020 and increase over four times by 2040.

If agricultural water is used for municipal purposes, it will require adequate treatment. Water in the Santa Clara River and the Virgin River above La Verkin Springs (Pah Tempe Hot Springs) is suitable for treatment for municipal use; however, water in the Virgin River below La Verkin Springs is too high in total dissolved solids (TDS) for drinking use unless it is treated by desalinization.

9.5.2 Secondary Systems

Secondary (dual) systems provide irrigation water for residential and municipal areas. Secondary systems allow the use of lower quality waters for landscape and turf irrigation. Parks, golf courses and other large grass areas are ideal candidates for secondary systems. Currently, most golf courses in the St. George area use unmetered secondary system water to supply most or all of their outside uses. Secondary systems are projected to serve future parks and golf courses in a manner similar to current practices. Projected diversions and depletions for secondary systems are shown in Table 9-4.

9.5.3 Irrigation Water

Agriculture has remained fairly constant over the past 20 years. As future population growth continues, some of the new development will displace presently irrigated farmland. The displaced agricultural irrigation water from this urbanization could be used for 1) irrigation of new lands or supplemental water supply of existing land experiencing a shortage, 2) conversion to municipal and industrial uses including secondary (dual) water systems and/or 3) remain in the streams or reservoirs for aesthetics, conservation pools for recreation and wildlife values. Projected irrigation water use is shown in Table 10-6.

TABLE 9-4
CURRENT AND PROJECTED SECONDARY WATER USE

Year	County			Total	
	Iron	Kane	Washington	Diversion	Depletion
		(acre-feet)			
1990	0	1,250	14,710	15,960	11,170
2000	0	1,720	23,670	25,390	17,770
2010	0	2,080	31,550	33,360	23,540
2020	0	2,370	37,810	40,180	28,130
2040	0	3,240	61,790	65,030	45,520

The major source of water for most of the presently irrigated lands is surface water. About 10 percent comes from wells.

If irrigation water from Washington Fields is transferred for use on new croplands, one location could be in Warner Valley. This would require a pump lift of about 500 feet from the St. George-Washington Fields Canal diversion to Warner Valley. This amount of pumping would substantially increase the cost of crop production. Lands just above the existing canal could be irrigated with only small pump lifts.

Because of the high total dissolved solids (TDS) of La Verkin Springs, the most likely use for the Washington Fields displaced water would be secondary (dual) water systems for parks and golf courses.

If irrigation water from displaced cropland in the Hurricane and La Verkin areas is not applied to new or existing lands, it could be treated for municipal use or used in secondary systems. This is currently being done in part of the Hurricane area where there is a new secondary system.

Displaced irrigation water from the Santa Clara River could be used in a secondary system or be treated for culinary use. The water could be purchased for a larger conservation pool in Gunlock Reservoir and/or used for aesthetic and recreational values.

As agricultural lands in the Kanab area are taken out of production for subdivision developments, the water can be put to other uses. Again, water is needed for secondary water systems, supplemental irrigation water and municipal and industrial water.

9.5.4 Recreational Water Demands

Recreation offers diverse leisure opportunities. The basin contains four state parks, one national park, one national forest and two wilderness areas. The recreational activities range from camping, hiking, nature study, hunting, golfing and water sports in the summer to cross-country skiing, snowmobiling, hunting and sledding in the winter. Sightseeing is aesthetical at any time of the year with majestic rock formations at Zion National Park and Snow Canyon, beautiful lakes at Gunlock and Quail Creek reservoirs, dense green forest with beautiful fall colors in Dixie National Forest, drifting sand dunes and cliffs at Coral Pink Sand

Dunes and mile after mile of backcountry administered by the Bureau of Land Management.

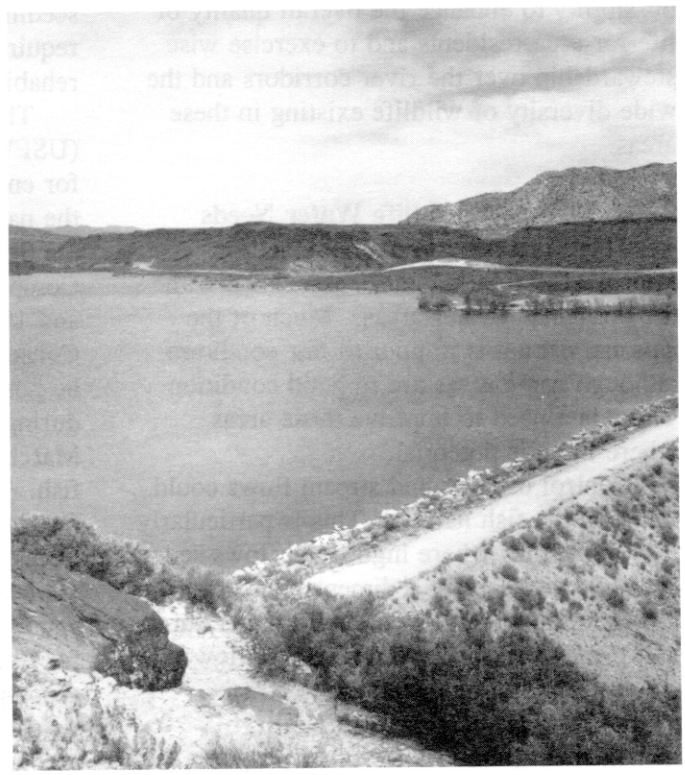
Gunlock State Park at Gunlock Reservoir is located on a paved secondary road between the small communities of Veyo and Santa Clara. The park is within 30 minutes of St. George, 90 minutes from Cedar City and two hours from Las Vegas, with the majority of the park's visitation coming from these areas.

Gunlock Reservoir and dam were built on the Santa Clara River in 1970 by the Lower Gunlock Reservoir Corporation. The dam is 117 feet in height, creating the reservoir's storage capacity of nearly 11,000 acre feet. The maximum surface acreage of the reservoir is 266 acres, with a mean depth of 77 feet and 5.1 miles of shoreline. This provides, along with other uses, recreational opportunities for several water-based activities. Demands for more and better facilities will increase.

Quail Creek Reservoir has a capacity of 40,325 acre-feet of water, a surface area of 625 acres and a water depth of 85 feet from conservation pool to the spillway. The dam spans Quail Creek at the notch where it flows through the colorful geological fold known as the Virgin Anticline.

Aside from its primary water storage purposes, Quail Creek Reservoir offers water-based recreational opportunities. As sponsor of the project, the Washington County Water Conservancy District provided $1.2 million for development of recreational facilities at the reservoir. Additional recreational facilities will be needed as time progresses.

The Virgin River Corridor Greenways Project goal is to designate a corridor along the Virgin and Santa Clara rivers, and to implement a trail system within the corridor. The system is proposed to run from Zion National Park to St. George along the Virgin River, and along the Santa Clara River to Gunlock State Park. Tributaries of these rivers and linear parks within the adjacent communities may also be included in the network. Eventually, the trail system may be connected with the Great Western Trail



which, when completed, will stretch from Canada to Mexico.

The Virgin River/Santa Clara River trail system will be comprised primarily of walkways. Equestrian and bicycle paths will also be included where possible. The optimum corridor width is 100 feet in order to allow for the accommodation of different trail types. The estimated length of the corridor is 76 miles. The location of the corridor will be determined in cooperation with property owners and government agencies.

The purpose of the project is to provide greater opportunities for the enjoyment of the natural amenities of the area to residents and visitors alike. It also offers the possibility to enhance the overall quality of life for area residents and to exercise wise stewardship over the river corridors and the wide diversity of wildlife existing in these areas.

9.5.5 Fish and Wildlife Water Needs

There is a need to maintain and/or improve the riparian zones associated with the permanent water areas. Much of the riparian habitat is in poor to fair condition, although some areas are in good condition. There is a need to improve those areas where there is potential.

Control of river and stream flows could improve the fish habitat. This is particularly true in reaches where high flood flows scour channels and deposit sediment. This could also help maintain better water temperature and provide instream flows. Some flow fluctuations can be beneficial to stream channels. This can occur through management practices for other purposes. Even with regulation, flood water flows will still occur.

An additional demand for the water in the Virgin River, from La Verkin Springs to the Washington Fields Diversion, is the instream flow requirement for endangered species. To meet the requirement, water used for irrigation in Washington Fields must be diverted at or below their present diversion dam (See Section 6.3.1).

9.6 Water Supply Enhancement

There are several ways to enhance the water supply. These include constructing additional reservoir storage to reduce and conserve high flows for use during low flow periods, adopting water conservation and increased use efficiency, conjunctive use of groundwater and surface water, cloud-seeding, refining instream flow requirements, implementing watershed rehabilitation or a combination of these.

The U.S. Fish and Wildlife Service (USFWS) requires a minimum instream flow for endangered fish of the lessor of 86 cfs or the natural flow all months of the year above the St. George and Washington Fields Canal Company diversion. Studies between 1980 and 1985 by the Washington County Water Conservancy District have indicated it may be possible to reduce the flow to 50 cfs during the months of November through March without impacting the endangered fish. This could provide about 7,000 acre-feet of additional water yield from Quail Creek Reservoir.

Making more efficient use of existing water supplies can increase the availability for future demands. This can be accomplished by continuing to increase irrigation water use efficiencies, install secondary systems and better control of municipal and industrial water use. See Section 17.

9.7 Water Development and Management Alternatives

The Kanab Creek/Virgin River Basin has the most rapid population growth in the state. Population is projected to more than double by the year 2020. This will require wise planning and prudent use of the resources to meet future demands and anticipated needs in the basin.

9.7.1 Groundwater

The State Engineer considers the groundwater supplies fully appropriated with the exception of four areas. These are 1) Johnson Wash, 2) Kanab Creek, 3) west of Hurricane and south of the Virgin River, and 4) Beaver Dam Wash. Applications for appropriation in these areas are considered on their own merits. However, in the closed areas, a liberal change application policy has been adopted to alleviate the need for water in areas where there is merit.

There is increasing interest in the Beaver Dam Wash area as demands for water in the basin increase. Water planning is complicated by interstate interests in Utah, Arizona and Nevada. The three states, in cooperation with USGS, have initiated a joint hydrologic study of the Beaver Dam Wash area.

The area closed to new appropriation in the Virgin River basin includes most of the area underlain by the Navajo aquifer, perhaps the most dependable long-term supply and estimated to contain several million acre-feet of recoverable water.[2] Production from this source in excess of present withdrawals is considered groundwater mining, and is being discouraged by the State Engineer under current policy. Water is stored in other consolidated aquifers and the alluvium, but the volume has not been determined.

A possibility for additional groundwater use in presently developed areas is to control the recharge and/or discharge of the groundwater. Artificially increasing recharge to the groundwater reservoir from melting snow and during periods of heavy precipitation may be another productive means for increasing available groundwater. While this may be a viable option, downstream users will object if their water supply is adversely affected.

The supply of high quality water in the Navajo sandstone aquifer is especially vulnerable to pollution by the activities of people. This is because so much of the uncovered, potential recharge area of the aquifer outcrop has highly pervious sandy soil or lava flow surface layers and is located close to the populated areas in and near St. George. Public use of the outcrop areas should be controlled. Some areas, such as Snow Canyon State Park, are already protected. Other areas, such as City Creek, Middleton Wash and Mill Creek, are vulnerable and should be protected. Figure 9-2 shows the recharge zone to the Navajo sandstone aquifer in Washington County. More information on groundwater resources is given in Section 19.

9.7.2 Water Conveyance and Delivery Systems

Agricultural Water - Many of the irrigation companies in the Kanab Creek/Virgin River Basin have improved their water conveyance and delivery systems during the last number of years. These system improvements have consisted primarily of concrete canal lining and pipelines. Pipelines have been installed in

recent years to provide gravity/pump pressure for irrigation sprinkler systems.

Some irrigation companies have replaced or improved other facilities used to deliver irrigation water. These include diversion structures, canal improvements, pipelines, measuring devices, water control structures and other management facilities. More detail is given in Sections 10 and 17.

Municipal and Industrial Water - Many communities have been upgrading their culinary water supply systems. Nine have built new or additional storage tanks. Ten have replaced or developed additional sources of water. Fifteen have replaced and/or added distribution systems and made other improvements (See Table 9-1).

There are still communities where systems need to be upgraded. This includes new or additional water storage tanks and new or upgrading of distribution systems. This is required because of additional population growth and for fire protection. More detail is given in Section 11.

9.7.3 Water Storage Facilities

New water storage facilities will be needed to meet future water demands throughout the Kanab Creek/Virgin River Basin. Storage reservoirs not only increase the total supply available but make more efficient use of the existing water.

The Division of Water Resources completed an inventory in 1988 of 92 potential reservoir sites located in the Virgin River drainage. This report documents past investigations. In January 1992, the division completed an evaluation of the initial 92 sites plus 6 additional sites identified in the process.[10,12] Through a series of evaluations, which included geologic concerns, location problems and small capacity (less than 3,000 acre-feet), the list of potential sites was narrowed to 16.

In February 1993, the division re-evaluated 27 sites eliminated in the 1992 evaluation because their capacities were less than 3,000 acre-feet. Also, an additional site on Tobin Wash was evaluated. After an in-house geologic review, 16 of these smaller sites were considered feasible for additional investigation. Sponsors pursuing additional water should consider all 32 sites in their investigation of water supply alternatives. Detailed field investigations will likely eliminate some of these sites from further study. There may also be other sites not presently identified that could be evaluated in the future. These potential sites for the Virgin River drainage are summarized in Tables 9-5 and 9-6. Locations are shown on Figure 9-3.

Other reservoir sites have been proposed in the Kanab Creek and Johnson Wash drainages during various investigations. These potential sites are summarized in Table 9-7 and shown on Figure 9-3.

Other management alternatives, including potential storage reservoirs, are currently being studied. These are discussed in Section 9.7.5. Reservoir locations are shown on Figure 9-3.

9.7.4 Virgin River/Cedar City Transfer

During the early 1950s, a discussion between Iron County and Dixie Project officials was held to explore diverting Virgin River water into Cedar City. Because of potential delays, nothing was done. The Utah Water and Power Board then appointed a committee to consider the needs of Washington and Iron counties. After the Navajo Lake diversion was eliminated because of water rights issues, Cedar City

FIGURE 9-2
Potential Recharge Area, Navajo Sandstone Aquifer, Washington County, Utah

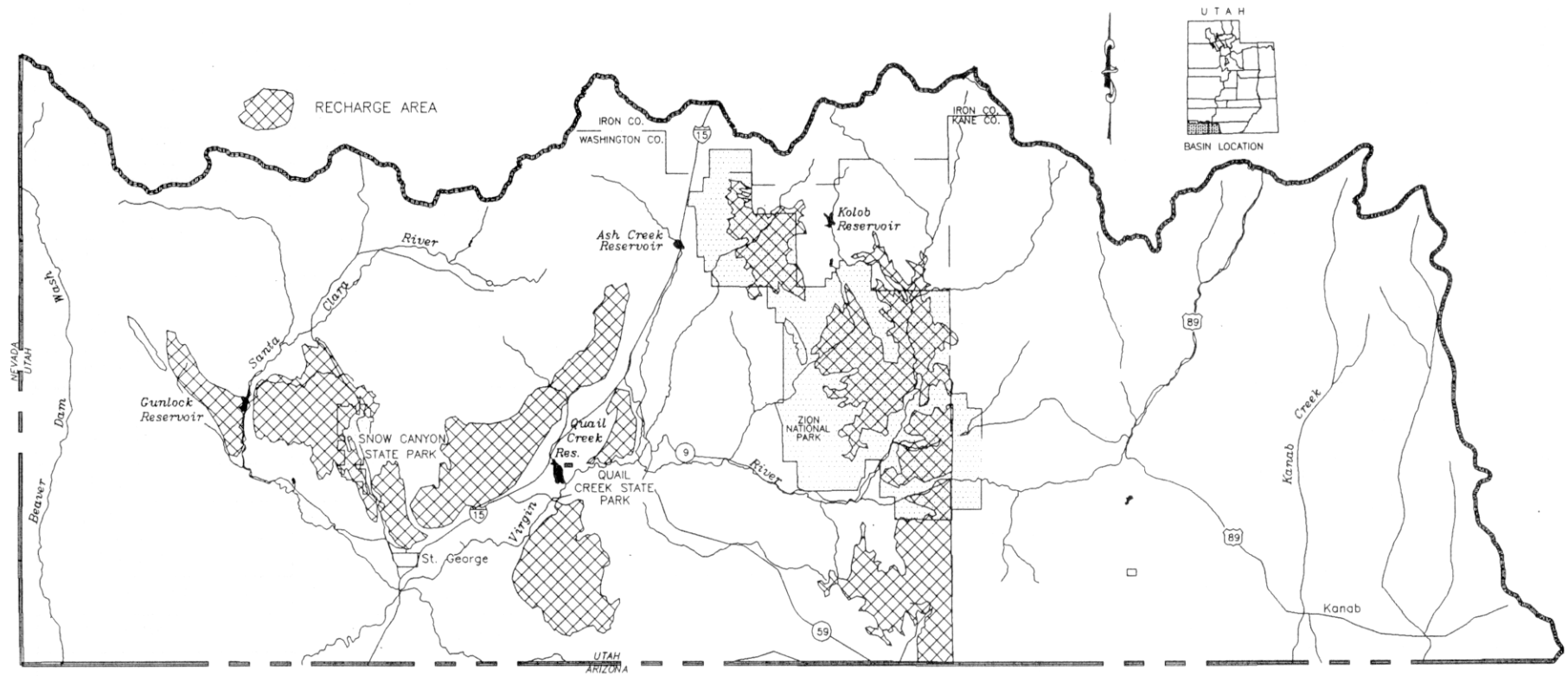


TABLE 9-5
POTENTIAL RESERVOIRS OVER 3,0000 ACRE-FEET[10,12]
VIRGIN RIVER DRAINAGE

No.	Site Name	Location			Dam Height (ft.)	Dam Crest Length (ft.)	Dam Crest Width (ft.)	Dam Embankment Volume ($yd.^3$)	Reservoir Storage Capacity (ac-ft.)	Max. Water Surface Elevation (ft.)	Reservoir Surface Area (ac.)	Land Ownership
		Tp.	Range	Sec.								
93	Stout Creek	39S	7W	35,36	170	840	39	1,660,000	6,000	6,440	94	BLM, Private
3	Lydia's Canyon	40S	7W	11	210	1,600	40	2,700,000	12,000	6,140	177	Private
94	Muddy Creek	41S	7W,8W	7,12	130	1,700	31	1,440,000	12,500	5,500	277	BLM, State
6	Long Valley	41S	8W	36	115	750	25	150,000[c]	19,000	5,180	170	BLM, State
90	East Fork	42S	8W	7	150	300	25	80,000[c]	12,000	4,960	262	BLM, (W.S.A.)[d]
15	Seth Canyon	38S	8W	31	150	1,300	35	1,860,000	5,000	7,280	81	Private
19	Hay Canyon	39S	8W	18	150	850	35	1,270,000	3,000	6,800	52	Private
22	Bullock[a]	39S	9W	32	144	650	34	860,000	8,500	5,700	154	BLM, State
32	North Creek[c]	41S	12W	14,23	125	1,400	30	1,012,000	13,500	3,660	225	BLM, Private
95	La Verkin	40S	12W	19	155	800	36	1,160,000	5,000	3,820	112	BLM, State
62	Warner Valley	42S	14W	28,29	240	3,250	53	9,240,000	55,000	2,940	264	BLM, Private
63	Fort Pierce	43S	14W	34	110	700	27	570,000	16,000	3,000	54	BLM
96	Gunlock Enlargement[b]	41S	17W	5	142	1,550	33	200,000	16,800	3,609	375	State
80	Santa Clara (Shem)	41S	17W	28	150	800	35	1,280,000	22,000	3,360	401	BIA
83	Lower Santa Clara	42S	16W	18	190	700	25	340,000[c]	18,000	3,000	294	BLM, State
97	Beaver Dam1	38S	20W	25	190	450	25	120,000[c]	18,000	4,800	302	BLM, Private

[a]Additional geotechnical and design data is available
[b]Gunlock Dam is currently 117 ft. high, 1,400 ft. long, and holds 10,884 Ac-Ft.
[c]Roller Compacted Concrete Dam Embankment Quantities
[d]Wilderness study area
[e]Site rejected by Bureau of Land Management in June 1993

TABLE 9-6
POTENTIAL RESERVOIRS UNDER 3,000 ACRE-FEET
VIRGIN RIVER DRAINAGE[10,12]

No. Site Name	Location			Dam Height (ft.)	Reservoir Storage Capacity (acre-feet)	Land Ownership
	Township	Range	Section			
2 Lower Swapp	39S	6W	16	*	*	State, Private
26 Deep Creek (Shopman Hollow)	38S	9W		*	*	State, Private
37 Meadow Hollow	38S	11W	16	*	*	State, Private
38 Willow Creek	38S	11W	15	*	*	State, Private
39 Big Water	38S	14W	11	36	234	Forest Service
40 Deep Flat Canyon	38S	14W	13	*	*	Forest Service
48 Mill Creek	39S	13W	29	*	*	Forest Service
49 Mill Harmon	39S	13W	32	*	*	Forest Service
52 Grape Vine Wash	40S	13W	31	*	*	State, Private
53 Jones Creek	40S	14W	26	*	*	Forest Service
54 Quail Creek (Leeds)	40S	14W	36	51	200	Forest Service
61 Washington	42S	15W	15	67	270	State, Private
71 Pilot Creek	38S	17W	29	*	*	Forest Service
72 Moody Creek	38S	17W	33,34	100	2,000	State, Private
84 Dry Wash	42S	16W	8	57	280	BLM
100 Tobin Wash	40S	17W	9	*	*	BLM, State

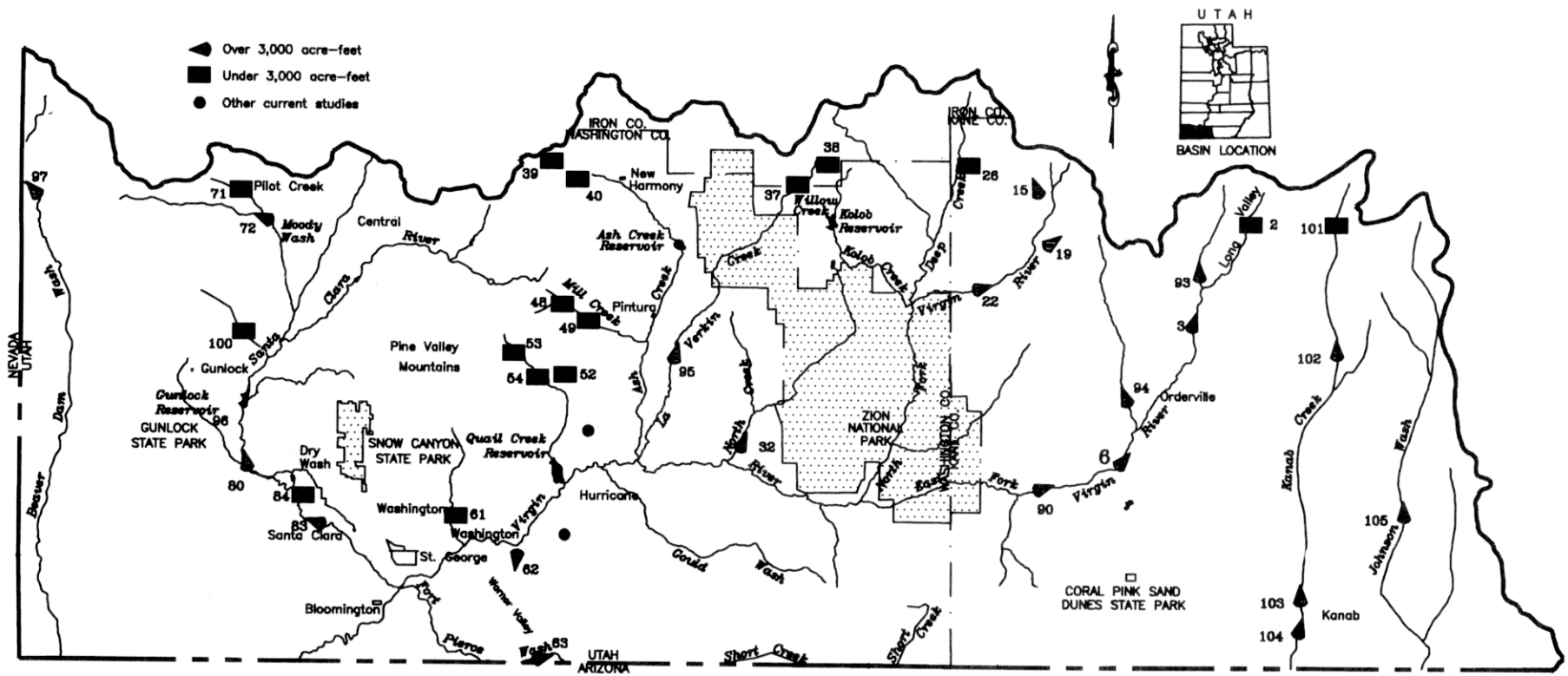
* No information is available. Additional evaluations are needed.

TABLE 9-7
POTENTIAL RESERVOIRS
KANAB CREEK/JOHNSON WASH DRAINAGE[1,7]

No.	Site Name	Location			Dam Height (ft)	Reservoir Capacity (ac-ft)	Land Ownership
		Twnship	Range	Section			
101	Alton	38S	5W	32	25	200	Private
102	Elbow	40S	6W	35	52	5,500[a]	BLM, Private
103	John R. Brown	42	6	29	115	7,000[a]	BLM, State, Priv.
104	Bridge	43	6	5	110	9,000	BLM, Private
105	Johnson Creek Wash	42S	5W	15	103	9,000[a]	BLM, State

[a] Other larger capacities investigated

FIGURE 9-3
Potential Reservoir Sites [1,7,9,10,12]
Kanab Creek/Virgin River Basin



looked at Kolob Creek in the Virgin River basin. In August 1953, Cedar City entered into an agreement with Washington County and the newly formed Kolob Reservoir and Storage Association (water users from Hurricane and Washington Fields). The agreement was to construct the Kolob Dam and Reservoir (capacity 5,500 acre-feet) with Cedar City repaying two-fifths of the cost of construction. This allowed Cedar City to acquire the entire water storage and supply in Kolob Reservoir when the Dixie Project was completed. When the Dixie Project was abandoned in the early 1960s, a substitute reservoir was needed.

A study was completed in 1982 by the Utah Division of Water Resources for conveying water from Kolob Reservoir to Cedar City and considering Bullock Dam for use by Washington County water users as a replacement supply for Kolob water. The project was presented to the Board of Water Resources in May 1982, but funding was never authorized.

In 1984, an agreement between Cedar City and Washington County Water Conservancy District (WCWCD) outlined opportunities for Cedar City to develop water in the Virgin River basin. A short summary of the agreement follows: Cedar City is repaying a portion of the costs of constructing Quail Creek Dam and Reservoir in exchange for the right to divert water from the upper Virgin River drainage for transbasin conveyance to Cedar City. Cedar City is thereby purchasing storage in Quail Creek Reservoir from WCWCD to provide 3,340 acre-feet annually to the Hurricane Canal Company and St. George and Washington Fields Canal Company. In exchange, Cedar City would have the right to divert the water developed and stored in Kolob Reservoir, as well as 1,600 acre-feet annually of Crystal Creek primary water and any high water right in Crystal Creek they can acquire. This agreement recognizes the first 600 acre-feet annually stored in Kolob Reservoir is reserved for prior downstream rights.

If transbasin conveyance is economically or environmentally infeasible, then Cedar City can divert up to 6,100 acre-feet annually from springs in the upper Virgin River basin. One restriction is not more than 533 acre-feet can be diverted per month during July, August and September. If Cedar City decides not to construct facilities for transbasin diversion of water from the upper Virgin River drainage, the WCWCD will reimburse Cedar City for the amount paid plus interest towards the cost of construction of the Quail Creek project. The WCWCD will then purchase Cedar City's two-fifths interest in Kolob Reservoir along with associated water rights and property.

This 1984 agreement is important to Cedar City because it allows full development of its water rights in the upper Virgin River basin. The agreement is important to the WCWCD because it specifies conditions and the time frame Cedar City must meet.

Cedar City and the Division of Water Resources completed a study in March 1993 to evaluate water supply, demand and development opportunities for Cedar City. The report includes an update evaluation of several transbasin diversion alternatives, some of which have been previously studied.

9.7.5 Water Supply Management

Even though much has been accomplished, there are additional opportunities to improve the management of

water resources. This applies to uses ranging from municipal, industrial and agricultural to instream flows.

Management includes increased delivery efficiency, reduced wasteful uses and prudent application of water for aesthetic purposes. Water managers should always be searching for ways to increase the available supply for all uses.

Computer modeling is one of the tools used in the planning and design of water projects. It is used to simulate river systems to determine reservoir yields, hydroelectric power production, water shortages and the affect on the river systems as new reservoirs become operational. Reservoir operation procedures can be developed to maximize the available water for use and minimize any problems associated with changing flow regimes.

Five management alternatives are under consideration or investigation. These are briefly discussed below.

The Kane County Water Conservancy District is investigating a reservoir for construction where U.S. Highway 89 crosses Kanab Creek. The estimated capacity is 9,000 acre-feet.

Three projects are being investigated by the Washington County Water Conservancy District. One is a proposal to divert La Verkin (Pah Tempe) Springs into a pipeline and return it to the Virgin River below the St. George and Washington Fields Canal Company diversion. This would improve the water quality for agriculture and provide for future conversion of Virgin River water for municipal purposes with conventional treatment.

The second is construction of an offstream storage reservoir in Sand Hollow west of Bench Lake Reservoir. This would maximize the potential of Bench Lake Reservoir and meet existing environmental requirements.

The third proposal is to pipe Ash Creek Reservoir, Leap Creek, South Ash Creek and Wet Sandy Creek to an offstream site near Anderson Junction with a capacity of about 10,000 acre-feet. This water could provide secondary water for Toquerville and La Verkin releasing Toquerville Springs for municipal and industrial uses. An alternate to the Anderson Junction site is one in Grapevine Wash with a storage capacity of 34,000 acre-feet.

The Soil Conservation Service is considering a debris basin in Gould Wash above Hurricane. This structure would capture flood flows in Gould Wash and release them at a lower rate. The only storage would be temporary flood water flows. This is a part of the Warner Draw Watershed Project.

9.8 Projected Basin Water Depletions

Kanab Creek and the Virgin River are interstate stream systems which pass through portions of Arizona, Nevada, and Utah prior to entering the Colorado River. The streams currently serve water users in the three states. Not only is it important to assess the available water resources and document current water demands, it is also important to project future long-range depletions to the river systems. Depletions are water losses to a basin or system other than by naturally occurring depletions for wetland and riparian vegetation, and surface water or groundwater outflow. These depletions occur in five major categories: irrigation of crops, M&I use from public systems, secondary use in municipal areas, water surface evaporation and exports.

TABLE 9-8
CURRENT AND PROJECTED WATER DEPLETIONS

Use	1990 (acre-feet)	2040
Culinary	10,580	51,280
Secondary	11,170	45,520
Irrigation	51,300	37,600
Exports	2,600	9,100
Reservoir Evaporation	5,300	8,400
Shivwits Paiute Indian Band	300	[a]
Total depletion	81,250	151,900

[a]Unknown. Depends upon ruling on reserve water rights.

Current and projected water depletions for the Virgin River Basin in Utah are shown in Table 9-8. Values are estimated for the year 2040. Irrigation uses are expected to gradually reduce as existing agricultural land is converted to new residential development. The converted irrigation water may be available to meet the future M&I water supply. The increase in exports includes the potential delivery of 6,500 acre-feet of water to Cedar City. (See Section 9.7.4).

Two separate activities are currently underway which may modify the diversion and depletion values shown in this section. Washington County Water Conservancy District is cooperating with local communities, Washington County and Five County Association of governments on a study to determine Washington County's ultimate population based on a total buildout concept. A similar study may be undertaken in Kane County. The Division of Water Resources is conducting a detailed study in cooperation with local communities to better determine M&I water diversions and depletions for the basin. As these activities/studies are completed, they will be evaluated and the basin plan updated as appropriate.

9.9 Cloud Seeding

Cloud-seeding is an acknowledged method of increasing the water supply within a selected area. It requires the right conditions to be the most effective. During prolonged dry conditions, this program may not produce significant increases in precipitation. Recognizing the need for development of additional water resources, the state, through the Division of Water Resources, has participated in a cost-sharing winter cloud-seeding project. The Utah Water Resources Development Corporation initiated the program in 1973. The development corporation represents participating counties and conservancy

districts (Beaver, Carbon, Emery, Garfield, Grand, Iron, Juab, Millard, Piute, Sanpete, Sevier, San Juan, Tooele, Wayne and Washington). Participating entities pay a large part of the funds needed to operate the cloud-seeding program.

The winter cloud-seeding project was designed to produce additional snowpack in the mountains and increase the subsequent spring runoff. By comparing the amount of precipitation in a seeded area (target) to that in a nearby unseeded area (control), it is possible to estimate the seeding effects. An overall increase of about 11 percent has been indicated. This difference, with a 95 percent probability, is due to cloud-seeding. These results compare favorably with other winter cloud-seeding programs. A conservative economic evaluation of this increase indicates water is being developed for about one dollar per acre-foot. ■

9.10 References

1. Bureau of Reclamation. *Reconnaissance Report, Kanab Creek Basin, Arizona-Utah.* Boulder City, Nevada, 1971.

2. Clyde, Calvin G., *Groundwater Resources of the Virgin River Basin in Utah.* Utah Water Research Laboratory for the Utah Division of Water Resources, Salt Lake City, Utah, 1987.

3. Cordova, R.M., *Ground-Water Conditions in the Upper Virgin River and Kanab Creek Basins Area, Utah, with Emphasis on the Navajo Sandstone.* Technical Publication No. 70, prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1981.

4. Cordova, R.M., G.W. Sandberg, and Wilson McConkie. *Ground-Water Conditions in the Central Virgin River Basin, Utah,* Technical Publication No. 40, prepared by the U.S. Geological Survey in cooperation with the Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1972.

5. Hardy, Thomas B., Brent Bartz, and Wendy Carter. *Population Dynamics of the Fishes in the Virgin River from 1984 through 1987 and Impact analysis of the Quail Creek and North Creek Reservoir System.* Utah State University, Logan, Utah, 1989.

6. Leslie and Associates. *Hydrological Study of Beaver Dam Wash Aquifers in Mohave County, Arizona.* Cedar City, Utah, 1990.

7. State Engineer, *Twenty-Second Biennial Report.* For the Biennium July 1, 1938 to June 30, 1940, Salt Lake City, Utah, 1940.

8. U.S. Department of Commerce, Weather Modification Advisory Board. *The Management of Weather Resources*. Washington, D.C., 1978.

9. U.S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin - Utah Cooperative Study*. Salt Lake City, Utah, 1990.

10. Utah Division of Water Resources. *Inventory of Reservoirs and Potential Damsites in the Virgin River Basin as Supplemented*. Salt Lake City, Utah, 1988, 1993.

11. Ibid. *Municipal and Industrial Water Diversion and Depletion for the Virgin River and Kanab Creek Drainage Basins*. Salt Lake City, Utah, (In preparation).

12. Ibid. *Preliminary Analysis of Potential Damsites in the Virgin River Basin*. Salt Lake City, Utah, 1992.

13. Utah Division of Water Rights, *Water Use Data for Public Water Suppliers and Self-Supplied Industry in Utah*. Reports 1-8, Salt Lake City, Utah, 1960-1989 (also 1990-1991 unpublished).

14. Utah Office of Planning and Budget, Demographic and Economic Analysis. *Utah Data Guide*. Vol. 10, No. 1, Salt Lake City, Utah, 1991.

15. Ibid. *State of Utah Economic and Demographic Projections - 1990*. Salt Lake City, Utah, December 1989.